imperfectly known, in spite of their comparative abundance, and some of the species are extremely difficult to identify. Out of a total of thirty-eight South African representatives of the family, no less than twenty-two belong to the genus Clinus, of which twelve are described by the authors as new. In the second paper a very large number of species belonging to sundry genera and families are named and described; one of these—referable to Chrysophrys—is locally known as the "Englishman," and the authors have accordingly named it *Ch. anglicus*, which scarcely seems a satisfactory designation for a South African species.

To the issue of the Proceedings of the Academy of Natural Sciences of Philadelphia for December, 1908, Mr. H. W. Fowler contributes a paper on the Pennsylvanian fresh-water fishes of the family Cyprinidæ, in the course of which a new species of Notropis is described. Owing to pollution of the streams, some species of these fishes are in danger of extermination.

Much has of late years been written on the development and life-history of the eel, a further addition to the subject being a paper, illustrated with figures and a map, by Mr. Knut Dahl, which appears in the January number of *Naturen*.

From fishes we pass to whales, the Arctic fishery for which during the past season receives a brief notice by Mr. T. Southwell in the *Zoologist* for January. Six vessels were dispatched for whaling purposes in 1908, two of which visited the Greenland seas, while three proceeded to Davis Strait and one to Hudson Bay. The Greenland fishery proved the most productive, yielding ten out of the fifteen right-whales constituting the season's catch. In addition to these, the season's expedition yielded 540 white whales, 899 walruses, 3084 seals, and 241 bears. With whalebone at about 2000*l*. per ton, the total value of the produce (inclusive of a cargo brought from Pond's Bay station by the *Eclipse*) may be estimated at between 29,000*l*. and 30,000*l*.

Turning to invertebrates, the first paper for notice is one by Dr. J. Stafford, of Montreal, published in the January issue of the *American Naturalist*, on the larva and spat of the Canadian oyster. The fact that American oysters are unisexual renders possible artificial fertilisation of the eggs and rearing of the larvæ, and these young stages have been long familiar to the naturalist, but there was a big gap in our knowledge between these stages and the fixed condition. Accordingly, the author set himself the difficult task of learning to identify oyster-fry amid the hundred forms of life to be met with in the pelagic plankton. In this he was eventually successful, having observed what he took to be the larvæ settle themselves on glass plates and develop into undoubted oyster-spat. Further study of the plankton will probably enable the height of the breeding-season to be definitely determined. At present it seems that oyster-larvæ occur in the water from July 11 to September 1, and that spat make their appearance from August 16, thus suggesting that during the second half of August there occur the last stages of growth of late larvæ, and that the period of growth of the masses dates from between July 11 and August 16. The eggs are therefore probably deposited about the first of July. The paper concludes with a summary of the results of the author's investigations, and also contains remarks upon the important bearing of these and earlier observations on the problems and methods of artificial oyster-culture.

The last two papers for notice are by Dr. Gilchrist, the one, in the above-mentioned issue of the Annals of the South African Museum, on two new species of Ptychodera, and the other, in vol. xvii., part ii., of the Transactions of the South African Philosophical Society, on new forms of Hemichordata from South Africa. In the former paper Dr. Gilchrist observes that, in addition to the under-mentioned *Ptychodera capensis*, another representative of the same genus is found in the same localities in fair abundance under stones, but usually somewhat nearer to high-water mark. Among the adult forms were found a number of smaller ones, in which the proboscis and collar were in all stages of development, this apparently indicating a process of natural fragmentation or proliferation from the tail end of this species, for which the name *Pt. proliferans* was accordingly suggested. The second, *Pt. natalensis*, is from the Natal coast, and is characterised, among other features, by the extremely short proboscis. *Pt. capensis* is described in the second paper.

In the latter paper it is mentioned that the three orders of the Enteropneusta are now known to be represented in South African waters, the Enteropneusta by the above-mentioned species of Ptychodera, the Pterobranchia by a species of Cephalodiscus, and the Phoronidea by a new species of the type-genus (*Phoronis capensis*), and by the new genus and species *Phoronopsis albomaculata*. The last-named, which is figured in its fully expanded form alongside *Phoronis capensis*, is an exceedingly beautiful organism, differing from the type-genus mainly in having an involution of the epidermis with definitely differentiated (cubical) cells. The involution occurs below the nerve-ring, which it partially covers, and passes round the body so as to encircle the mouth, vent, and nephrideal apertures.

MEANING AND METHOD OF SCIENTIFIC RESEARCH.[1]

IN this day of encyclopædias numerous and ponderous, one is often struck with the fact that in spite of the manifest care and conscientious thought bestowed by the responsible editors, the omissions and evidences of discontinuity of treatment, and lack of recognition of the prime purposes of the compilation, are as noteworthy as the imposing array of the results of our steadily advancing knowledge is startling. For a philosophic treatment—one fully appreciative of that which the student really requires, not only to enlighten him with regard to a particular subject, but also to stimulate him to research where it is most needed—I frequently get more satisfaction out of the older encyclopædias than from our modern ones, even though they can but present the status of the subject up to the time they were written.

As an illustration, take the word "research," or any of the associated terms—"discovery," "experiment," "investigation," and "observation." Turning to the index volumes of the ninth and tenth editions of the "Encyclopædia Britannica," I find but two references in which the word "research" appears—one to the exploring vessel, the *Research*, and the other to "research degrees." Turning to the page on which the latter occurs, we find this interesting statement referring to Oxford University:—

"New degrees for the encouragement of research, the B.Lit. and B.Sc. (founded in 1895, and completed in 1900 by the institution of research doctorates), have attracted graduates from the universities of other countries. In 1899 a geographical department was opened, which is jointly supported by the University and by the Royal Geographical Society." Now comes the interesting statement which I beg to emphasise:—"*Of more bearing on practical life are the Day Training College Delegacy* (1892) *and the diploma in education* (1896). *Under the former elementary school teachers are enabled to take their training course at Oxford, and do so in growing numbers,*" &c.

We thus see what the writer of this article thinks of the relative value in practical life of research foundations and normal school foundations! Sir Norman Lockyer, in his luminous inaugural address before the British Association for the Advancement of Science in 1903, on the "Influence of Brain-power on History," says:—"A country's research is as important in the long run as its battleships." Why, then, does not the standard encyclopædia of that country make space for a representative article on "research"?

Under "investigation" there also appears absolutely nothing. However, we have the *Investigator* ship, Investigator Shoal, Investigator Group, &c., but not a word about the general methods employed by "scientific investigators"; and so it is with the word "discovery"—there is no reference whatsoever to an article on the

[1] Abridged from an address by Dr. L. A. Bauer as retiring president. the Philosophical Society of Washington, delivered before the Society on December 5, 1908.

general principles leading up to discoveries. Likewise with the word "observation." Though there are many references to observations of various kinds, there is no one article for setting forth the general principles of "observations" or the part they play in the discovery of fundamental facts. The same experience is had with regard to the word "experiment."

Now let us turn to an encyclopædia I invariably read with pleasure and profit; it frequently has supplied me with references to earlier work not to be obtained elsewhere. We shall find it instructive, though the articles to which I beg to invite your kind attention were written three-fourths of a century ago. I refer to the classic Gehler's "Physikalisches Wörterbuch"—the revised edition by the noted investigators Brandes, Gmelin, Horner, Littrow, Muncke, and Pfaff, in twenty volumes, and published in Leipzig, 1825–45. A veritable fund of information is found under the headings "Beobachtung" (observation) and "Versuch" (experiment). The article on "Beobachtung," by the physicist Muncke, embraces twenty-eight octavo pages. He shows the distinction between "Beobachtungen" (observations) and "Versuche" (experiments) to be that the former pertain to the perceptions of phenomena presented to us by nature in her unmodified course, whereas in the latter—in the experiments—we are seeking to produce certain results or phenomena, more or less looked for, in order either to verify a law already known or to disprove one suspected of being wrong, or even to discover a new one. Both classes of experiences are necessary for a piece of investigation or research work.

Thus we may behold, either visually or in some other way, certain striking solar phenomena; these belong to the class of observations which we ourselves are unable to modify in any manner whatsoever. Continued observation may, however, reveal a certain law which by experiment in the laboratory, conducted along more or less definite lines, we may seek to imitate in the hope of getting some clue to the *modus operandi* of the observed phenomena. In this article on "observations" the author treats in detail the various elements entering into correct methods of investigation, condition of the observer and of his senses, his being unbiased, character and errors of the instruments, errors of results, methods of increasing accuracy, representations of observations by graphs and formulæ, method of least squares, &c. He points out the mistake sometimes made that an established formula satisfying the observed phenomenon within certain limits represents an actual law of nature.

The article "Versuch" (experiment) consists of forty-four pages, and is contributed by the astronomer Littrow. He shows that the most rapid development takes place in those sciences which afford the greatest opportunity for experimentation, referring, *e.g.*, to the slow and painful progress of the astronomer so long as he had to confine himself to mere celestial observations, and the comparatively rapid strides which occurred so soon as some of the observed phenomena could be either imitated by, or be compared with, those derived by laboratory experiment. The investigator, he says, must be absolutely free from preconceptions, and be careful, cautious, and unbiased in his interpretation of what his senses may reveal to him. He illustrates how man, called jokingly "das Ursachenthier" (the animal ever bent on ascertaining the cause of things), proceeds in ferreting out the why and wherefore of observed phenomena, and how his methods of circumspection develop with the advance of knowledge.

Though man cannot determine the "Endursachen," or ultimate causes of things, the field open to him to discover the laws governing phenomena or *vice versâ*, classifying and enumerating those which follow a certain revealed law, is, nevertheless, still very large and sufficient to tax his energies. Witness, for example, the host of observed phenomena obeying the law of inverse squares!

These two articles will show sufficiently the character and scope of similar ones we should like to see in our standard English and American encyclopædias.[1] Such information is contained in some measure, at least, though not as comprehensively, in the modern German book of reference, Brockhaus's 'Conversations-Lexikon," as also in the "Grande Encyclopédie" of the French.

[1] Chambers's Encyclopædia is found to contain a short article on "Experiment"; also one on "Observation."

Our foremost English dictionaries are in general not any more satisfying or edifying regarding the precise meaning of "research" in the scientific sense than are the standard encyclopædias. Their illustrations of the use of the word are usually neither apt nor sufficiently comprehensive.

A good-sized chapter might be written on the "mathematical instruments or tools of research." The predominating tendency of resolving or expressing every natural phenomenon—periodic or otherwise—by a Bessel or a Fourier series or by spherical harmonic functions has brought about at times, especially in geophysical and cosmical phenomena, if not direct misapplications, at least misinterpretations of the meaning and value of the coefficients derived.

Frequently by the purely mathematical process there have been eliminated, in the attempt to represent a more or less irregularly occurring natural phenomenon by a smoothly flowing function, the very things of chief and permanent interest. The normal or average diurnal temperature curve, for example, or a uniform magnetic distribution over land, so as to yield perfectly regular lines of equal magnetic declination, never occur in nature. There is thus being impressed upon us more and more forcibly the fact that what we have been regarding as "abnormal features"—the outstanding residuals between observations and the results derived from the mathematical formula—are in truth not "abnormal" from the standpoint of nature, but are rather to be taken as indicative of the "abnormality" or "narrow-mindedness," which means the same thing, of ourselves in trying to dictate to nature the artificial and regular channels she should pursue in her operations.

Louis Agassiz said:—

"The temptation to impose one's own ideas upon Nature, to explain her mysteries by brilliant theories rather than by patient study of the facts as we find them, still leads us away."

The fundamental law of nature is to follow invariably the paths of least resistance, and by examining these lines of structural weakness of the opposing systems we may have opened to us the very facts which are to be of real value and of sure benefit to mankind. The irregularity of the banks bordering a natural watercourse serves to differentiate the work of nature from that of the builder of the artificial and regular channel.

No, instead of rejecting, we must learn to retain the outstanding residuals and study them most carefully and regard *them* as the true facts of nature, and not those which we so egotistically and presumptuously try to force on her. What great discoveries may lie open to us when we once have grasped the true significance of the facts we have been so fond of measuring by our own standard and have been terming as "abnormal" or "irregular"!

An interesting example of not wholly successful application of the continuous and ever-recurring functions of spherical harmonics to a typical geophysical phenomenon —the distribution of magnetism over the earth's surface —has been discussed by me elsewhere. Though the number of unknowns has been increased in recent computations from the original twenty-four of Gauss to forty-eight, nevertheless the difference between theory and observation is of such an order of magnitude as to preclude the use of the formula for even the purely practical demands of the navigator and surveyor. Nor has anyone succeeded in giving any physical interpretation of the laboriously derived coefficients beyond the first three. And what do these three stand for? The simplest possible case of a first approximation to the actual state of the earth's magnetism, viz. that of a uniform magnetisation about a diameter inclined to the axis of rotation!

The prime difficulty here may be summed up in a word. The very surface over which the spherical harmonic functions are spread is itself such a prolific source of disturbance as to cause effects embracing a continent, a State, or a locality. Such a large number of terms would be requisite for an adequate representation as to make their

computation prohibitive. We are dealing here with more or less discontinuous effects that cannot be imitated by continuous functions without leaving behind a train of residuals, precisely as though we were to try to fit to the actual configuration of the earth some standard pattern of our own. Let me ask what phenomenon have we, in fact, which will admit of the determination of forty-eight, or even of twenty-four, physical constants?

It had been my intention to say a few words on the value and limitation of that much-used as well as abused mathematical instrument of research, the method of least squares. Properly employed, it is a most useful adjunct to investigation; but, as intimated, the true significance of formulæ established by this method is at times pushed way beyond the limitations. What the tenor of my remarks might be will be sufficiently evident to you if I submit this query for your consideration, What actual laws of nature have been discovered by the method of least squares?

It is an extremely interesting and suggestive fact that the greatest experimental discoveries to-day are not made in the older, well-recognised sciences, but on their border-lands—in the "twilight zone" of more or less related sciences. I have but to mention the words "physical chemistry," "physical geology," "astrophysics," "bio-chemistry," &c., and you will readily grant the assertion made. In the overlapping regions there seem to be the greatest opportunities afforded for solid, thorough, and at the same time remarkably rapid, experimental achievements; and so we are having produced almost daily new specialities or new subspecialities.

What is the effect on the general broad-mindedness of man of this extreme specialisation, so necessary for the production of the best and most far-reaching results? *Is the modern specialist more narrow-minded than the generalist of a century or two ago?* In view of the fact that the prime instrument of research is, after all, the mind, the question is not an irrelevant one. We find statements occasionally made which would imply an affirmative answer to our question; but I, for one, would most emphatically protest against such an inference. I should maintain that the specialist, other things being equal, is likely to be a broader man than he who has no speciality, but simply a general knowledge of some particular science. The reason for my positive statement would be found in the fact mentioned, that the greatest part of the research work to-day is being done on the border-lands of the general sciences, for he who wishes to take part in this very active competition must needs be far better equipped than the mere generalist. The physical chemist, to be most successful, must have a very intimate knowledge of both physics and chemistry, and the more mathematical skill he possesses the better. The astrophysicist must be a physicist, a chemist, a mathematician, besides being an astronomer. And so with regard to the geophysicist.

Only a few names need be cited—like those, for example, of Faraday, Maxwell, Kelvin, von Helmholtz, Mascart—to support the contention that the broadest physicists are, as a rule, those who have regarded their laboratory experiments and deductions therefrom merely as a means to an end, not an end in themselves, and who have accordingly sought to apply the knowledge gained to the solution of some of the great problems affecting the general welfare of man. There is the greatest need in America of well-trained and well-equipped physicists in the solution of the many perplexing problems of the earth's physics with regard to the phenomena of seismology, vulcanology, meteorology, atmospheric electricity, terrestrial magnetism, &c. When the investigator makes the attempt to apply some of his laboratory facts to geophysical and cosmical phenomena, he has opened to himself a world of which he never dreamed; he finds zest in familiarising himself with the fundamental facts of other sciences in which until now he could take no interest.

It is always interesting to know what was the precise course followed in the discovery of a great law. However, no two investigators have ever pursued, or at least but rarely, precisely the same paths, and we must therefore be content with the statement of the general principles of research such as has already been given.

A prevalent fault is observed in scientific publications whenever the investigator has had good training only on the observational side, and but very little experience in scientific computing. He is very apt to violate one of the first and fundamental principles of good observing, viz. to employ such a method or scheme of observing as will yield but one definite result, and that with the highest possible accuracy and with the least amount of computation. Oftener than may be thought, schemes of observation are used which leave an arbitrary element to the computer, and in consequence a different result is forthcoming, according to who makes the computation. Had we time, apt illustrations could readily be given from published works. The point made, that the observer must also bear in mind the computation side, and work up his results as soon as possible, is of fundamental importance in research work.

It may be worth while to consider briefly the insatiable desire of the analyst to ring in a series of sines and cosines to resemble the course of some natural phenomenon of which he does not know the exact law. Is this the old story over again, though in somewhat altered garb, of the epicycles and deferents of ancient astronomical mechanics, which received its highest development in the Ptolemaic system of the universe? You will recall that Ptolemy, building on the suggestions of Apollonius and of Hipparchus, supposed a planet to describe an epicycle by a uniform revolution in a circle the centre of which was carried uniformly in an eccentric round the earth. By suitable assumptions as to his variable factors he was thus able to represent with considerable accuracy the apparent motions of the planets and to reproduce quite satisfactorily other astronomical facts. This was the artifice employed by the astronomer of the period before the modern and more subtle art of simulating nature, by the sine-cosine method, had become known.

What seemed so intricate and complex in Ptolemy's time could be expressed in very simple language indeed, when a Kepler discovered the true functions as embodied in his three fundamental laws. The present method of hiding our ignorance of the real law seems at times to exert such a mesmerising influence as to make us mistake the fictitious for the real.

Of course I do not mean to discard this useful and, in fact, indispensable tool of research, but simply wish to direct attention to its limitations and to the importance of not overlooking the fertile by-products, the residuals, which, because of our neglect of them, may some day rise and smite us in their wrath. Each one of us at one time or another has doubtless established, by least squares, an empirical formula of some kind which so beautifully fits the observations as to make us bold and venturesome. Now comes a new observation, somewhat outside of the range for which the expression was established. Eagerly the test is applied, and we find to our chagrin that the formula on which so much work had been spent will not fit the new result, and that we have a "counterfeit" and not the real law.

Let us suppose, for illustration, we are dealing with a phenomenon which almost entirely unfolds itself during the time between sunrise and sunset—the well-known diurnal variation of the earth's magnetism is a striking case of the kind. Following the usual method, the phenomenon is resolved into component parts with the aid of a Fourier series. The formula as generally adopted includes the four terms having, respectively, periodicities of 24, 12, 8, and 6 hours. For ordinary magnetic latitudes the striking result is obtained that the second term—the 12-hour one—is as important as the first, or 24-hour, one; so we might equally as well say "the semi-diurnal" as "the diurnal variation of the earth's magnetism." In fact, as the semi-diurnal term unfolds itself twice in twenty-four hours, it is in reality more important than the purely diurnal one.

Does the resolution into Fourier terms of a phenomenon of the kind given really prove their existence in nature? Can we conclude, without question, *e.g.*, that in addition to the diurnal term we also have a semi-diurnal one? Even with four terms the series does not represent each hourly observation of the twenty-four with the same degree of precision. In fact, the residuals for the night hours are nearly of the same order of magnitude as the observed quantities. If the physical existence of the 12-hour term

is not proved, then there is no need of racking our brains as to its physical origin.

The difficulty disclosed by this example is of the same kind as the one treated in spherical harmonics, viz. that we are attempting to represent a discontinuous function having a duration commensurate with that of the daylight hours by functions running smoothly through their individual courses for twenty-four hours.

I cannot close this section better than by quoting the following passage from the address of the first president of this society, Joseph Henry, given on November 24, 1877:—

"The general mental qualification necessary for scientific advancement is that which is usually denominated 'common sense,' though, added to this, imagination, induction, and trained logic, either of common language or of mathematics, are important adjuncts. Nor are the objects of scientific culture difficult of attainment. It has been truly said that the 'seeds of great discoveries are constantly floating around us, but they only take root in minds well prepared to receive them.'"

Henry's insistence on the application in our scientific work of "common sense" reminds one of Clifford's apt definition of science as being "organised common sense."

It may be taken as almost axiomatic that whatever is worthy of investigation should be made known in some effective manner, so as to reach without question those concerned. The multiplicity of literature on any one subject, or even on any small portion thereof, is nowadays such that the worker finds it utterly impossible to keep abreast of publications, even those in his own field, to say nothing of kindred ones.

He is forced more and more to rely on abstracts—at least in so far as to direct him to that which he unquestionably must consult in the original, if possible. As the investigator usually finds it necessary to consult the original publications, the next conclusion to be drawn is that the publication of any research work should, in general, be of such form and size as to permit the widest distribution possible, not only among the libraries and the principal seats of learning, but also among the workers and institutions immediately interested.

The scientific worker generally does not possess the means to purchase or to construct the instruments he requires for the prosecution of his work, and a book bearing in any way on the line of work to be pursued is as much to be considered part of his equipment as the purely mechanical tools. Indeed, I was told by the late von Bezold that Wilhelm Weber set his laboratory students to work by telling them, "Here are the instruments, and there are the *Annalen der Physik*; now go to work." The man of science usually wants his tools close by and within ready reach. He cannot afford to go to a distant library and then possibly find the book out. Private possession permits him, furthermore, to make marginal notes and references to enable him quickly to put his finger on the very thing needed.

Owing to these well-recognised needs, there has grown up a courteous and friendly interchange of publications among co-workers and sympathisers in the same field that to my mind deserves the highest encouragement. The time has unfortunately gone when scientific investigators can write such delightful and voluminous letters as passed between the research workers of half a century and more ago. The present system of interchange of publications has necessarily taken the place, to a very large extent, of the early letter-writing.

It is as important to make research work known as to do it. To get our friends to read the contributions we may make to science requires nowadays no little skill and diplomacy and an attractiveness of literary style on the part of the author not so essential in the days of less frequent printed works. The original purposes of important and costly expeditions are sometimes well-nigh defeated or superseded, because of the delay in publication, ensuing from the elaborateness of the plan adopted for the reduction of the field results and the form of publication decided upon. Reduction in the pretentiousness, size, and cost of scientific publications appears to me to be one of the greatest needs of research to-day.

Some time could profitably be spent on a consideration of the general agencies engaged in furthering research work and the methods employed for doing so. Being connected with a "research institution," I should consider myself incompetent to enter upon a free and unbiased discussion of the methods of such organisations for the furthering of research work. I will, however, take as an example the general magnetic survey of the earth as representative of the kind of world-embracing research enterprises I have in mind.

Alexander von Humboldt, whose mental grasp was extraordinary in more than one science, set forth the following plan in his "Cosmos" for a general magnetic survey of the globe.[1]

"Four times in every century an expedition of three ships should be sent out to examine as nearly as possible, at the same time the state of the magnetism of the earth, so far as it can be investigated in those parts which are covered by the ocean. . . . Land expeditions should be combined with these voyages." . . .

"May the year 1850 be marked as the first normal epoch in which the materials for a magnetic chart shall be collected, and may permanent scientific institutions (academies) impose upon themselves the practice of reminding, every twenty-five or thirty years, Governments, favourable to the advance of navigation, of the importance of an undertaking whose great cosmical importance depends on its long-continued repetition."

Here was a noble project, universally conceded to be not only of the greatest scientific interest, but also of the greatest practical importance. Yet why is it that this grand plan has never been carried out by the foremost nations in friendly concert? Have our academies, as Humboldt suggested, never "imposed upon themselves the practice of reminding every twenty-five or thirty years Governments, favourable to the advance of navigation, of the importance of an undertaking" of this character?

Instead of working along a common and definite plan, the magnetic operations hitherto have consisted of more or less isolated and incomplete surveys, independently undertaken by various nations and distributed over a great number of years. Not even for a single epoch has it been possible to construct the magnetic charts on the basis of homogeneous material, distributed over the greater part of the earth, with some attempt, at least, at uniformity. As to the possibility of constructing the charts, with the aid of similar data, for epochs twenty-five to thirty years apart, as Humboldt had dreamed, this, in spite of the enlightened interest of many countries, is even more remote.

Why should it have remained for a purely *research* organisation to undertake a problem touching so keenly as this on even the so-called sordid, purely practical interests of man? Is it a fortunate fact that Humboldt's fascinating international scheme failed of execution, and that the chief brunt of the work is now being borne by a single organisation? The magnetic work of the Carnegie Institution of Washington has embraced, since 1904, a general magnetic survey of the Pacific Ocean, and land observations have been made in more or less unexplored regions in different parts of the world. The ocean magnetic work is to be undertaken next in the Atlantic Ocean, in 1909, on a specially built vessel, the first of its kind.

It is believed that an effective scheme of operation has been evolved, with the aid of the valuable advice received from eminent investigators. Without danger of giving offence to anyone, it is possible to deal directly with the officials concerned, submitting to them our plans and ascertaining whether they contemplate doing anything similar, and, if so, whether, in case their funds are insufficient, they could suggest some friendly basis of cooperation between their organisation and ours. This plan of action has met with entire success thus far. Duplication, overlappings, and possible jealousies are all avoided; and in countries where no organisation whatever exists to do the work, we are free to go ahead and finish the task in less time than it would necessarily take to get an official action or official consensus of opinion from a large scientific body.

Slow deliberation in terrestrial magnetic work would be disastrous, for the prime reason that the phenomena of investigation in this field of research are continuously

[1] The quotation is from E. C. Otté's translation of the "Cosmos," vol. ii., pp. 719-20.

undergoing change. The time-element in the earth's magnetism, even for a period of a few years, is of such moment as completely to mask the fine, hair-splitting points which would necessarily and rightly have to be raised on some international mode of action, to say nothing of the painful and cumbersome method which would have to be employed to conform with the rules of official correspondence between nations. Many a well and carefully executed magnetic survey in the past has had its full importance for world-wide investigation destroyed because of the possibility of error in the secular variation corrections which must be applied to bring its results up to the date of the later data.

The course pursued by the Carnegie Institution of Washington in conducting the general magnetic survey of the globe is the only way in which this particular project, and similar ones to it, could not only be expeditiously conducted, but also realise the chief objects of the work. This policy, briefly stated, is to make, with the aid of the friendly and harmonious cooperation of all concerned, a rapidly executed magnetic survey of the greater part of the globe, so that a general survey, all-sufficient for the solution of some of the great and world-wide problems of the earth's magnetism, will be completed within a period of ten to fifteen years. At a smaller number of points, selected in consideration of the prime questions at issue, the observations are to be repeated at intervals of five years or less, in order to supplement the rather sparsely distributed magnetic observatory data. Thus the determination of the corrections for reduction of the general work to any specific date is continuously provided for.

The most evident result of all magnetic work in the past is that, for the purposes of a general survey, it is far better to make some sacrifice in accuracy if thereby it is made possible to secure observations at another point. In other words, the errors due to local disturbing conditions are far greater than the purely observational ones. Hence multiplicity of stations rather than extreme accuracy and laborious methods of observation and reduction is the prime requisite.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The general board of studies has approved Prof. E. C. Stirling, F.R.S., and Prof. W. Ridgeway, Disney professor of archæology, for the degree of Doctor in Science.

The council of the Senate has appointed Prof. Biffen as a representative member of the John Innes Horticultural Institution for four years from February 8.

OXFORD.—The vacancy in the Waynflete professorship of mineralogy at Oxford has been filled by the appointment of Mr. H. L. Bowman, of New College, who for many years acted as demonstrator under Prof. H. A. Miers.

On Friday, February 12, the hundredth anniversary of the birth of Charles Darwin was celebrated at Oxford by a reception given in the examination schools by Profs. Vines, Poulton, and Bourne. The proceedings were opened by the Dean of Christ Church, acting for the Vice-Chancellor, who was unavoidably absent. In the course of an interesting address on fifty years of Darwinism, Prof. Poulton spoke of the various influences which had moulded Darwin's career, dwelling especially on his early friendship with Henslow, to whom was due what proved to be the turning point in Darwin's life—his appointment as naturalist to the *Beagle*. The support and encouragement given to Darwin by Lyell, Hooker, and Asa Gray, and the vigorous championship of Huxley, were passed in review, special mention being also made of the chivalrous conduct of Wallace in seeking to minimise his own claims as joint discoverer of the principle of natural selection. The famous contest at the meeting of the British Association at Oxford in 1860 was touched upon, and the lecturer took occasion to contrast the matured views which, after being tested during twenty years of reflection and investigation, at last found expression in the publication of the "Origin of Species," with the hasty and ill-informed impressions of Darwin's early critics. Much of the rapid success of Darwin's theory in gaining acceptance at the hands of the scientific world was due to the personality of its author, whose noble qualities of mind and character were shown alike in his dealings with opponents, with friends, and with younger workers in his own subjects. All this work was accomplished in spite of constant bodily exhaustion from ill-health, to which cause the lecturer was inclined to attribute the lack of appreciation of literature and music in later life, which Darwin himself recognised and deplored. No upheaval in the realms of human thought had carried with it more of immediate pathos and of ultimate triumph than the doctrine of organic evolution, now and always to be associated, first and foremost, with the name of Charles Darwin. Among the assembly on Friday were four of Darwin's sons, Mr. William Darwin, Sir George Darwin, Mr. Francis Darwin, and Major Leonard Darwin. Sir George and Mr. F. Darwin briefly addressed the meeting, confirming the account given by Prof. Poulton of their father's genius and character. In the course of the evening a telegram was received conveying "the greetings of Cambridge zoologists, assembled in Darwin's old rooms, to their Oxford colleagues."

DR. O. V. DARBISHIRE has resigned his lectureship in botany at the University of Manchester.

PROF. HENRY A. MIERS, F.R.S., principal of the University of London, will present prizes and certificates to students at the South-Western Polytechnic Institute, Chelsea, S.W., on March 12.

THE eleventh annual dinner of the Central Technical College Old Students' Association will be held on Saturday, February 20, at the Trocadero. Dr. H. T. Bovey, F.R.S., Rector of the Imperial College of Science and Technology, will be one of the chief guests.

BOWDOIN COLLEGE, at Brunswick, Maine, U.S., has recently received funds amounting to something more than 100,000*l.*, given by a former student at the college, Mr. Joseph Edward Merrill, a business man of Boston. A few weeks before his death in January Mr. Merrill transferred a large part of his property to the college, and bequeathed practically all the rest of his estate to the same institution by his will. Bowdoin College, it may be remembered, was the alma mater of Nathaniel Hawthorne, of Henry W. Longfellow, of President Franklin Pierce, of the late Speaker Thomas B. Reed, and of the present Chief Justice of the United States, Melville W. Fuller.

A BILL has been introduced in the Wisconsin Legislature, says *Science*, which proposes to increase the building fund of the University of Wisconsin from 40,000*l.* to 60,000*l.* annually, and to lengthen the period of this appropriation from five to seven years. From the same source we learn that a new industrial fellowship has been presented to the University of Kansas by the Holophane Glass Co. It yields 300*l.* a year for two years, together with 10 per cent. of the profits that may arise from any discoveries made by the student who pursues special study. The fellowship is open to students of any university, but the work will be done in the laboratories of the University of Kansas.

A REPRESENTATIVE selection from the exhibits in the British Education Section of the Franco-British Exhibition held last year at Shepherd's Bush, London, has been on view at the Belfast Municipal Technical Institute during the past three weeks. Admission was free, and to explain the purport of the exhibition a series of explanatory addresses by educational experts was arranged. The Belfast Library and Technical Instruction Committee is to be congratulated upon securing the loan of these instructive exhibits from the various education authorities concerned, and it is satisfactory to know that the illustrative specimens, collected at the expenditure of much time and trouble by the authorities of the Franco-British Exhibition, are being placed at the disposal of the great educational institutions in our chief centres of population.